RAS 8486

September 10, 2004

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE SECRETARY

In the Matter of ENTERGY NUCLEAR VERMONT YANKEE L.L.C. and ENTERGY NUCLEAR OPERATIONS, INC. (Vermont Yankee Nuclear Power Station)	Docket No. 50-271

DOCKETED
USNRC

September 17, 2004 (10:15AM)

OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

Secretary
United States Nuclear Regulatory Commission
Washington, DC 20555-0001
ATT: Rulemakings and Adjudications Staff

Dear Rulemakings and Adjudications Staff:

Enclosed please find for filing in the above captioned matter an original and two copies of a **CORRECTED PAGE TWO OF ARNOLD GUNDERSEN'S DECLARATION IN SUPPORT** of **NEW ENGLAND COALITION'S REQUEST FOR HEARING, DEMONSTRATION OF STANDING, DISCUSSION OF SCOPE OF PROCEEDING AND CONTENTIONS**.

Also please find for filing in the above captioned matter, **NEW ENGLAND COALITION'S SUPPLEMENTAL EXHIBIT "G", ENTERGY REPORT CR-VTY-2004-0918, " MSIV AS-FOUND LLRTs SHOW AND ADVERSE TREND."**

The subject report was referenced in Mr. Gundersen's Declaration, but not included as an exhibit because New England Coalition believed that both the licensee and NRC staff had copies of the report in their possession. On September 8, 2003, New England Coalition received a request from counsel for Entergy for the report, erroneously labeled in Mr. Gundersen's Declaration as "Exhibit B." As we are providing a copy of the report to counsel for Entergy, we would now like to provide a copy for the record and the State of Vermont, for the convenience of NRC staff as **SUPPLEMENTAL EXHIBIT G** .

We regret that we do not have an electronically scanned version of **SUPPLEMENTAL EXHIBIT G** .

The document was obtained by New England Coalition through a Freedom of Information Act request and is referenced in NRC's ADAMS website under, **FOIA/PA-2004-0267 - Resp 1 – Partial** – "E- mail from L. Lukens of Vermont Yankee to D.

Template = SECY-037

SECY-02

Pelton of USNRC, regarding MSIV LLRT Adverse Trend (32 pages). We were however unable to locate an electronic copy of the document in ADAMS.

Service to all parties is also been provided to all parties via First Class U.S. Mail.

New England Coalition sincerely regrets any confusion or inconvenience this inadvertent omission and late submission of this exhibit may have caused NRC or the parties.

Thank you for your consideration,
Sincerely,

Raymond Shadis
Pro Se Representative
New England Coalition
Post Office Box 98
Edgecomb, Maine 04556
207-882-7801
shadis@prexar.com

Main Steam Isolation Valves

The safety function of Main Steam Isolation Valves ("MSIV") is to close and maintain an essentially leak-tight barrier to the release of containment atmosphere.

In anticipation of Extended Power Uprate (EPU) and in response to Condition Report-VTY-2004-0918, MSIV As -Found LLRTs Show An Adverse Trend , Entergy proposes to increase the allowable ,as Found, Local Leak Rate Test ("LLRT") Main Steam Isolation Valve leakage from 44scfh to 62scfh. Further, Entergy proposes to adopt a less conservative test methods than that which presently yields an adverse trend in MSIV LLRT failures. I believe this proposed change would result in a reduction in safety margin even at the present power level.

If the requested power uprate is approved, the change in allowable MSIV leakage during testing would mask the increased vulnerability of the MSIVs to leakage and/or loss of function due to warping and/or or binding under a power uprate. According to Entergy, "Flow induced damage can include valve stem bending, valve stem disc separation and damage to the guide ribs." (*Id.* at 27) Therefore, it poses an unacceptable safety risk.

Since 1973, as shown in a 2004 Entergy report, the LLRT MSIVs have been tested 23 times. CR-VTY-2004-~~0917~~ 0917, "MSIV As-Found LLRTs Show an Adverse Trend" at page 17, (May 5, 2004) (hereinafter "MSIV Test Report"). ~~A copy is attached as Exhibit B.~~ (Entergy e-mailed this report to NRC on May 6, 2004.) Between 1973 and 2004, there have been 14 LLRT MSIV test failures. *Id.* at p.17 Of these failures, four occurred in the first 23 years from 1973-1996. During the last eight years, ten failures occurred. *Id.* at p.17.

Entergy attributes the increased failure rate after 1996 to more conservative test methods. According to Entergy, "[t]he low incidence of MSIV failures prior to 1996 is ... the result of non-conservative test method.... The validity of this method relies on a number of assumptions that could not be verified..." MSIV Test Report at page 11.

Entergy also concluded that "[t]he As Found LLRT history for MSIVs shows an adverse trend over the past four refueling outages. In RFO-21, there were zero; in RFO -22 there was one; in RFO 23 there were two; in RFO-24 there were three." *Id.* at p 1. Entergy believes that the appropriate solution to the problem of the increased MSIV test failure rate is raise the leakage limits in accordance with Entergy's pending alternate source term license amendment." *Id.* at page 2.

I disagree with Entergy's diagnosis of the reason for the increased LLRT MSIV test failure rate. In my view, the MSIVs are failing at an increasing rate because they are aging and corroding.
Various statements in the MSIV Test Report support my view`. At page 12, Entergy states that "... there is also a consensus that the Wye pattern globe valve[1] is less than optimal from a design and application point of view..." At page 8, Entergy states that

[1] This pattern of valve features a stem that enters the pipe at an angle, typically about 45 degrees.

EXHIBIT G

Pelton, David

From:	Lukens, Larry
Sent:	Thursday, May 06, 2004 9:41 AM
To:	Pelton, David
Subject:	MSIV LLRT Adverse Trend

Dave,

The Disposition for CR-VTY-2004-0918 is attached.

Please do not hesitate to contact me if you have questions.

CR-VTY-2004-0918,
MSIV LLRT Ad...

Larry

L. D. Lukens, Sr Engineer
Plant IST Coordinator
Entergy Nuclear Vermont Yankee
llukens@entergy.com
(802) 451-3131

A-201

Position Paper
Concerning The
As-Found LLRT of V23-3 & V23-4

Ref: PP 7006, Primary Containment Leak Rate Testing Program (PCLRTP)
ER 2001-0901

History:

Prior to or during RFO-23, V23-3 and V23-4 (HPCI Turbine Exhaust Check Valves) are required to be As-Found Local Leak Rate Tested (LLRT) to fulfill a required action of ER 2001-0901, V23-3 and V23-4 local leak rate test results exceeded acceptance criteria. The event report (Level1) resulted in a Licensee Event Report (LER 01-02). The event report's FOLLOW-UP VERIFICATION requires testing of these valves at the next refueling outage (RFO 23).

When the event report root cause analysis was being conducted, the existing valves were being refurbished and upgraded. Some parts had been determined to be insufficient for the application. The expectation was that the upgrade plus some TLC (tender-loving-care) during the transport of the valves would restore the valves to an acceptance performance level. Bench testing validated the refurbishment and upgrade restored acceptable seat leakage characteristics.

Following the upgrade, an additional problem was encountered during the post maintenance testing. The vertically mounted valve failed the As-Left LLRT. This problem was resolved by a reduction in the bolting torque applied on the inlet flange of the outboard check valve. Empirical testing demonstrated that a reduction in applied torque reduced the seat leakage rate and conversely an increase in the applied torque increased the seat leakage rate.

The valve was accepted by the PCLRTP Coordinator since the problem was reproducible and correctable, being predicated on the applied torque to the inlet flange bolting. The acceptance logic was that the valve body or seat base was being distorted/twisted by the increase in applied torque, and that the reduction permitted the valve body or seat base to return to a less distorted/twisted condition. Once the valve body becomes static, the obturator seating condition should not change except for seat deterioration. The PCLRTP monitors seat leakage (i.e., deterioration).

During RFO 23, V23-3 and V23-4 are being replaced (a modification) with an updated design due to the susceptibility for valve body (seat base) to distortion/twisting. The need for replacement of the existing valves was developed after the event reports were reviewed and approved by PORC and the Vice President of Operations. The development of the replacement modification did not require nor address the testing required by the event report. Presently, VY has no process that drives a re-assessment, the amendment, nor re-presentation of an event report to eliminate or modify pre-determined corrective actions (e.g., the As-Found LLRT requirement).

Discussion:

Primary Containment Isolation Valves V23-3 and V23-4 are local leak rate tested each refueling outage to support the Inservice Testing Program for obturator movement requirements of ASME/ANSI OMa-1988, Part 10, 4.3.2.4(a). As such, these valves are characterized in the program as Prescriptive (based) Assets. Prescriptive Assets are not required to be As-Found tested prior to maintenance or modification. Only Performance (based) Assets are required to be As-Found tested. Satisfactory As-Found testing maintains the basis for the extension testing frequency. There is no technical or regulatory requirement to As-Found test V23-3 and V23-4 other than those commitments identified in the ER and LER.

Minimal benefits can be derived from the As-Found testing of the existing valves since:

- Valves are being replaced with an essentially different style valve
- Valves are being discarded
- No autopsy is presently planned
- The testing requires outage time and resources

The only benefit that can be envisioned is the validation of Cycle 22 valve operability. However, valve operability is determined as a prerequisite to the mode switch change for start–up. No additional conditions existed prior to start-up from RFO 22, during the operating cycle, or prior to start-up from the MCO that would have compromised V23-3 and/or V23-4 from fulfilling the containment integrity function as tested and accepted during RFO 22.

Recommendation:

The As-Found LLRT and subordinate commitments be deleted from ER 2001-0901.

ADVERSE TREND COMMON CAUSE ANALYSIS REPORT

CR Number: CR-VTY-2004-0918 **Category:** ☒ A ☐ B

Assigned Department: ENG SYS Code Programs

Investigation Team:

Name	Department	Function
Larry Lukens	Code Programs	Team Leader
Rich Rusin	Component Engineering	Management Sponsor
Mike Annett	System Engineering	Member
Larry Prill	J. A. FitzPatrick	Member
George Short	Training	Mechanical Maintenance Background; MSIV Experience; Training Representative; RCA Qualified
Jim Taylor	Technical Support	Mentor; RCA Qualified

Date Report Completed:

☐ **The CR was caused by or identified an equipment/component failure.**
(If YES, complete VYAPF 0009.06 (Equipment Failure Evaluation Checklist) in accordance with Appendix M.)

☐ **The CR involved one or more HU inappropriate acts.**
(If YES, complete VYAPF 0009.05 (ENVY Human Performance Evaluation Form) in accordance with Appendix H.)

Problem Statement:

There is an adverse trend in as-found leakage rate results in main steam isolation valves at Vermont Yankee.

Executive Summary:

The as-found LLRT history for MSIVs shows an adverse trend over the past four refueling outages. In RFO-21, there were zero as-found MSIV LLRT failures; in RFO-22 there was one; in RFO-23 there were two; and in RFO-24 there were three.

This investigation looked at the safety implications of this adverse trend to determine whether or not this adverse trend challenges the operability of MSIVs or their ability to perform their intended safety function, which is to close and maintain an essentially leak-tight barrier to the release of containment atmosphere. The results of this investigation are that there are no challenges to the safety or reliability of MSIVs or their ability to perform their safety function. The adverse trend in MSIV LLRT failures is the result of factors unrelated to the ability of MSIVs to perform their safety function.

1. The actuator does not provide sufficient force to ensure a leak-tight seal when tested in the reverse direction.
2. The test method penalizes both the inboard and the outboard valves, resulting in LLRT failures that do not reflect the ability of the valves to perform their safety functions.
3. The current Technical Specification leakage limits for MSIVs are unnecessarily low and result in LLRT failures that do not reflect the ability of the valves to perform their safety functions.
4. Since this combination of factors presents an unrealistically difficult condition for leakage rate testing, maintenance on MSIVs must be raised to an uncommonly high level of precision.

This evaluation concludes that the MSIVs at Vermont Yankee are fully capable of safe, reliable operation. They are operable, and they are capable of fulfilling their containment isolation function. Maintenance and design enhancements were implemented in the five MSIVs that were worked on in RFO-24, and Fluid Design, with concurrence from System Engineering and Code Programs, has determined that there are no operability concerns with the three MSIVs that were no worked on in RFO-24.

Immediate corrective actions included the following:

- Repairing the three MSIVs that failed the as-found LLRT.
- Installing packing enhancements in 5 MSIVs: the 3 that failed the as-found LLRT and 2 others that had evidence of stem scoring
- Successfully retesting of all 5 MSIVs that were worked in RFO-24

Long-term corrective actions include the following:

- Formalizing maintenance practices and lessons learned into a procedure for MSIV valve maintenance and a separate procedure for MSIV actuator maintenance
- Implementation of higher MSIV LLRT leakage limits in accordance with the pending alternate source term (AST) license amendment.
- Implementation of an improved MSIV LLRT test method, as permitted by the pending AST license amendment.
- Review of the MSIV valve and actuator design in cooperation with the manufacturer, looking for opportunities to enhance MSIV performance.

CR-VTY-2004-0918
"MSIV As-Found LLRTs Show An Adverse Trend"
Adverse Trend Common Cause Analysis

Report Narrative:

EVENT DESCRIPTION

On April 4 and April 5, 2004, shortly after reaching a reactor coolant temperature less than 212°F, all eight MSIVs were as-found tested for leakage in accordance with the requirements of Technical Specification 4.7.A.4, PP 7006, and OP 4030. The results of the as-found testing were that 4 MSIVs had leakage rates less than 11 standard cubic feet per hour (scfh), and 4 MSIVs initially had leakage rates greater than 23 scfh. The acceptance criterion, given in Technical Specification 4.7.A.4, is = 23 scfh through each MSIV, and the combined maximum path leakage rate (MXPLR) for all four main steam lines is =46 scfh. As a result, the Action Limit for MSIVs is established by Vermont Yankee at 11.5 scfh. If no MSIV exceeds 11.5 scfh, then the combined MXPLR for all four lines will not exceed 46 scfh. If the leakage for an individual valve pair (inboard and outboard in the same line) is less than 11.5 scfh, the individual leakages are not typically determined, since the MXPLR for the line is less than 11.5 scfh.

Four Condition Reports were initiated for these four LLRT failures. In addition, a CR was initiated when it was identified that the 'B' main steam line inboard valve, V2-80B, had a galled stem that prevented valve motion. It has been determined that the valve became galled subsequent to the shutdown, since it stuck in the process of opening subsequent to the initial closure following reactor shutdown, and subsequent to the as-found LLRT. Although the leakage through the inboard valve, V2-80B could not be individually measured, it has been determined that the inboard valve had excessive leakage and that stem binding leading to imperfect seating was the failure mechanism (see CR-VTY-2004-955). It has also been determined by test that the outboard MSIV in the 'B' main steam line has a leakage rate less than 1.0 scfh. The initial apparent failure of the outboard valve is a consequence of the method used to separate outboard MSIV leakage from inboard leakage in a given main steam line. Therefore, there were actually 3 as-found MSIV LLRT failures in RFO-24.

With the number of as-found MSIV LLRT failures increasing linearly over the past 4 refueling outages, it was apparent that an adverse trend exists. It was the specific objective of this investigation to determine whether there is a common or similar cause that may call into question the long-term reliability and operability of the main steam isolation valves at Vermont Yankee.

All three MSIVs that failed their as-found LLRT in RFO-24 were disassembled and reconditioned. Only MSIV 80B had an internal condition that provided clear evidence of a failure mechanism (CR-VTY-2004-955). The other two MSIVs had what is characterized as "minor service-induced degradation." In addition, two other MSIVs were disassembled and refurbished, based on minor stem scoring. All 5 MSIVs that were disassembled were modified with an enhancement to optimize packing and stem alignment in the stuffing box (WOSE 2004-030)

All five valves successfully passed the as-left LLRT on the first attempt, indicating that the maintenance lessons learned over the past two refueling outages have been effective at reducing MSIV rework.

On the basis of demonstrated effective maintenance (successful as-left LLRT on the first test), it is concluded that the corrective actions taken during RFO-24 were effective at improving MSIV LLRT performance. Therefore, all 8 MSIVs are fully mission-capable and are ready for plant restart. Additional corrective actions will further improve MSIV LLRT performance.

This evaluation considered the following:

- Safety of the MSIVs; that is, whether or not the MSIVs are capable of performing their required safety functions.
- Whether the actions taken during RFO-24 can be reasonably expected to provide improved as-found LLRT performance in RFO-25.
- Causes of LLRT failures and corrective actions that would reduce the number of LLRT failures.
- Vermont Yankee is intolerant of unanticipated failures, and this adverse trend must be reversed.
- Emergent work for MSIV repair presents a burden to outage resources and a challenge to planning and scheduling.

This evaluation concludes that the MSIVs are fully mission-capable. Based on the success of the as-left testing performed following maintenance, all eight MSIVs are expected to maintain acceptable performance during the upcoming fuel cycle.

BARRIER ANALYSIS RESULTS

TIME LINE

The Common Cause team was able to assemble the as-found MSIV LLRT results for Vermont Yankee going back to 1973, the year of commercial operation (Attachment 1). Attachment 5 shows by RFO and by year the number of as-found MSIV tests that exceeded 23 scfh.
Attachment 5 shows that in the 23 years prior to 1996, 4 MSIVs exceeded 23 scfh on their as-found LLRT, and that in the 6 years since 1996, 10 MSIVs exceeded 23 scfh on their as-found LLRT. That is, in the past 6 years, the number of MSIV as-found LLRT failures is 2.5 times what it was in the first 23 years of plant operation. A significant amount of this investigation was directed at determining why the LLRT performance of MSIVs changed after 1996.

Prior to 1996, the MSIV test method was a pressure buildup method conducted at 26 psig in the accident direction. Beginning in 1996, MSIVs have been tested by the makeup flow method by pressurizing between the inboard and outboard valves. This results in a reverse-direction test on the inboard valve, which, although conservative, unnecessarily penalizes both the inboard and the outboard valve recorded leakage rates (Attachment 2). It has been shown that 1 MSIV as-found failure of the 10 since 1996 is directly attributable to test method. Three others failed because the individual MSIV leakage rate limit was 11.5 scfh, which is unnecessarily restrictive.

BARRIER ANALYSIS

Attachment 4 is the Barrier Analysis Worksheet. The barriers that could have prevented this adverse trend are the following:

Procedures – There is no controlled procedure for maintenance of MSIVs. Existing proceduralized Packing Guideline (OP 5281) is too generic to address specific requirements for the MSIVs. For example, stuffing box dimensional checks are measured in inches as opposed to the nearest 0.001" and necessary stem centering/alignment techniques during valve packing are not addressed.

Change Management – When the MSIV LLRT test method was changed in 1996, there was insufficient appreciation of the potential for the change to have an adverse effect on MSIV leakage rate test results.

CR-VTY-2004-0918
"MSIV As-Found LLRTs Show An Adverse Trend"
Adverse Trend Common Cause Analysis

EVENT ANALYSIS

The following facts were identified, either through records research or interviews:

1. GE Specification 21A1062AC includes performance specifications for MSIVs. This specification was sent to the valve manufacturer, who certified that these specifications were met. These valves were procured as ASME Section III Class 1 components, and their performance requirements included the following:
   - Reliability: "The estimated number of operating cycles per year is 50 to 400 cycles" "The Seller shall take as a design objective that the valves shall have an extremely high level of reliability and an extremely high immunity to the effects of foreign objects upon valve closure."
   - Maximum pressure drop: The pressure drop at rated flow with the valve wide open shall not exceed 6.0 psi.
   - Leak tightness at 40 psig in the accident direction: " A low pressure air seat leakage test shall be conducted on each valve....The maximum permissible leakage rate shall be 0.1 scfh per inch of diameter of nominal valve size."
   - Leak tightness at 1000 psig in the accident direction: 2cc. per inch of seat diameter per hour at design pressure.
   - Ability to open against pressure: "the valves shall be capable of opening with a 200 psi differential across the plug...."
   - Ability to close against pressure
   - Closure speed: "The valve shall be capable of closing in 3 seconds...."
   - Closure speed adjustment: " The valve should be capable of being closed within 3 to 10 seconds...."
   - Hydraulic dampening at the end of the close stroke
2. The asbestos packing that was originally supplied with the valves was replaced with graphite packing in 1989. A 3.625? carbon steel spacer was installed above the stellite "junk ring" to provide the correct packing stack height, since the 5-ring graphite packing replaced the old packing which contained 10 asbestos rings (5 above and 5 below a lantern ring).
3. The original 3/8 inch stellite "junk ring" was left in all 8 MSIVs in 1989. In 1996, these stellite junk rings were removed from V2-80A, V2-86A, V2-80C, and V2-86D. The 3.625? carbon steel spacer was replaced by a 4.041? carbon steel spacer to maintain the correct dimensions in the stuffing box.
4. Prior to 1996, MSIVs were tested in the accident direction (pressure gradient from the reactor side to the outboard side) at a reduced pressure of 24-26 psid, using the pressure-buildup method.
5. Prior to 1996, MSIVs routinely passed LLRT for 6 to 8 consecutive refueling outages, and when they failed, the cause of the failure was clearly evident to the Maintenance personnel.

6. In 1996, it was identified that the MSIV test method did not comply with the Vermont Yankee licensing basis. Technical Specification 4.7.A.4 specifies the MSIV LLRT acceptance criterion, "when tested at =24 psig." The only reduced-pressure testing method acceptable to the ANSI standard governing leakage rate testing is a reverse-direction test. Therefore, the reduced pressure test in the accident direction that had been used prior to 1996 was not compliant with Technical Specifications. CR-VTY-96-0077 was initiated; LER 96-04 was submitted to NRC; and the test method was changed for the 1996 outage to the present method, where the inboard MSIVs are tested by the makeup flow method at reduced pressure in the reverse direction, while the outboard MSIVs continue to be tested at reduced pressure in the accident direction (the "between the valves" test method).
7. Since 1996, MSIVs typically pass LLRTs for 2 to 4 consecutive refueling outages, and when they fail, the cause of the failure is not clearly evident to the maintenance personnel.
8. In 1998, the junk ring and the 3.625? carbon steel spacer were replaced with a 4.041? spacer in the remaining 4 MSIVs .
9. Live-loaded packing was installed in the 'B' and 'C' steam line MSIVs in the 1998 outage (RFO-20); the live-loaded packing modification was made to the 'A' and 'D' MSIVs in 1999 (RFO-21).
10. A modification to prevent stem-disk separation was installed in 1998 and 1999 coincident with the live loaded packing assemblies. The 'B' and 'C' MSIVs were done in 1998, and the 'A' and 'D' MSIVs were done in 1999, coincident with the live-loaded packing modification.
11. Starting in RFO-23, the MSIV seating surfaces have been "skim-cut" prior to lapping to establish a factory-new angle and finish on the seating surfaces. This practice was instituted after lapping alone failed to produce consistent LLRT results.
12. Smart Stem glued-on strain gauges were applied to MSIV stems in 1998 and 1999. This provided the ability to measure stem forces in the valve, particularly the seating force when the valve closes. This modification was concurrent with the other modifications made in 1998 and 1999.
13. Typical seating forces, measured by the stem sensor strain gauges are 18,000 to 20,000 lbf. This seating force has been shown by experience and by test to produce leak-tight seating.
14. It can be shown by analysis that since 1996 4 MSIV LLRT "failures" actually had leakage less than 23 scfh.
15. It has been determined that since 1996, MSIV V2-80B has experienced a galled stem twice, and in both cases, the galled stem caused or contributed to the LLRT failure.
16. BWROG Licensing Topical Report NEDC-31858P, approved by NRC, and referenced as part of the VTY alternated source term license amendment (BVY 03-70), concludes that MSIV leakage could be increased to 200 scfh per main steam line without inhibiting the safety function of the MSIV. NEDC-31858 also found that a leakage rate of 200 scfh for an MSIV does not represent abnormal or excessive leakage for a valve of this size and type.
17. The flow area that will pass 100 scfh at 26 psig is equivalent to an orifice with 0.054? diameter. The flow area that will pass 23 scfh at 26 psig is equivalent to a 0.026? orifice.
18. The only foreign material that has been positively identified in MSIVs is red rust.

19. Since 1996, only 2 MSIV as-found LLRTs have exceeded the 100 scfh "minor leakage" criterion: MSIV 80C in 1998; and MSIV 80B in 2004 (Attachment 3). Both failures had readily identifiable mechanical causes.
20. The root cause analysis performed for CR-VTY-2002-2211/2212 identified 13 potential mechanisms or factors that could lead to LLRT failures. These are discussed in Attachment 6.
21. Attachment 7 lists the causes identified for the MSIV as-found LLRT failures from 1996 through 2004.

CONCLUSION

The conclusion of this investigation is that there is an adverse trend in as-found MSIV LLRT performance, starting in 1996 (RFO-19). Some as-found MSIV LLRT failures are due to clearly identifiable mechanical causes. Two MSIV failures were attributed to mechanical binding caused by valve stem misalignment. Another cause of this adverse trend is the MSIV LLRT test method. And some failures have no detectable common or similar cause. The cause is not design, application, environment, or maintenance practices. Each of these factors was proposed and evaluated for its validity (Attachment 6). No single causal factor explains all the as-found MSIV LLRT data since 1996. The elimination of this adverse trend requires corrective actions that address those failure mechanisms that have been identified, as well as corrective actions that continue to monitor the effectiveness of the actions.

Although the design of the installed MSIVs is less than optimal for a BWR MSIV, valve design by itself cannot account for an excessive as-found LLRT failure rate or for the adverse trend experienced at Vermont Yankee. The common factors that emerged from this investigation are the following:

- Maintenance – a recognition that MSIVs have extremely tight tolerances for several critical dimensions is a relatively recent awareness in the BWR industry. The manufacturer's criteria for some of these tolerances have been reduced since 1998. At Vermont Yankee, the disassembly, measurement, refurbishment, and reassembly process has not been sufficiently formal to ensure that appropriate actions are taken to maintain these identified critical dimensions.
- Acceptance Criteria – The manufacturer has stated that the current leakage acceptance criteria are unrealistic and cannot be consistently achieved. Licensing Topical Report NEDC-31858P concludes that 200 scfh is not abnormal or excessive for valves of this size and type. Plants with acceptance criteria of 23 scfh per valve or less have as-found failure rates at least twice as high as those plants that have acceptance criteria of 100 scfh per valve.
- Test method – All 4 plants in the BWROG survey with low acceptance criteria test between the MSIVs at reduced pressure. Only one plant responding to the BWROG survey (Duane Arnold) tests in the accident direction at accident pressure. The average leakage rate for that plant's MSIVs is "less than 20 scfh," according to the survey response. Therefore, Duane Arnold's LLRT success is due to more than high acceptance criteria. It is reasonable to attribute some of their success to the test method that most closely duplicates the expected conditions following an actual closure to isolate the containment.

- Valve Design – The valves were specified, designed, and manufactured to be safe and highly reliable. In service, they are safe and adequately reliable. However, they require more maintenance due to failed LLRTs than is consistent with a valve with considerable design tolerance. The valve design is not tolerant of less-than-optimal test methods or minor deviations from certain critical dimensions. The valve actuator produces a seating force of approximately 18,000 to 20,000 lbf. The same valve (V10-27A, B) in the RHR system with a motor operator has a seating force of over 140,000 lbf. The RHR valves do not have leakage rate failures. There is not a single CR in PCRS documenting a leakage rate failure of either V10-27A or V10-27B. Because the seating force in the MSIVs is marginal, leakage rate results become susceptible to a number of service conditions that are less than optimal. For instance, reverse-pressure testing, which reduces the total seating force by nearly 4,600 lbf may result in excessive seat leakage. The valves also have several critical dimensions which have tolerances as small as 0.001? in some cases. If these dimensions are not within tolerance, it results in adverse effects on the measured valve leakage rate. It must be emphasized that the seating force during an actual containment isolation event would be greater than the force exerted by the actuator alone. Therefore, the marginally sized actuator penalizes minor imperfections in the valve during LLRT but does not affect the valve's ability to perform its safety function.

Causes of the Condition:

Common Cause

No single cause can be shown to meet the tests for a common cause. The causes listed below each partially account for the identified failures, and when corrected, these corrective actions can reasonably be expected to reduce LLRT failures to an acceptable level (less than 1 per RFO). Therefore, this adverse trend does not have a single common cause. It has four contributing causes.

Contributing Causes

CC-1 **[F.4.b.2] Document Use Practices; Procedure Not Followed Correctly**
CR-VTY-2002-2211/2212 identified CC #1 as B.5.a.2, "No procedure/document; procedure/document needed but has not been written. The root cause evaluation contained a corrective action commitment to "...incorporate lessons learned in an ENVY procedure." Contrary to the wording of the corrective action, this commitment was closed as complete after developing work order step text for MSIV work. A procedure is still needed and still has not been written. A separate CR (CR-VTY-2004-1499) has been initiated to address this inappropriate closure. The lack of a formal procedure is directly responsible for out-of-tolerance measurements being recorded on a WO in RFO-24 and no action being taken. This could not have happened if the requirements were in a controlled procedure with acceptance criteria. In addition, the critical evolution of centering the bonnet on the valve body is not proceduralized. It is performed by experienced personnel who remember how it was done the last time.

CC-2 **[O.3.z.2] Testing: Other. The MSIV LLRT acceptance criterion is unnecessarily restrictive and produces failure determinations for valves that have minor and inconsequential leakage.**

It was recognized in the 1990s that the MSIV LLRT acceptance criterion of 11.5 scfh was unnecessarily restrictive. A Technical Specification amendment was submitted and approved to raise the limit to the present 23 scfh per valve and 46 scfh total MXPLR for all 4 steam lines. It was further recognized that many BWRs have MSIV acceptance criteria of 100 scfh per valve or higher. Eight BWRs responding to the BWROG survey reported that they have limits of 100 scfh or higher. Nine BWRs responding to the BWROG survey reported that they have limits between 11.5 and 46 scfh per valve. The pending Alternate Source Term (AST) License Amendment will provide a maximum leakage through an MSIV of 62 scfh. Had this criterion been in place since 1996, there would have been a total of 3 as-found MSIV failures between 1996 and 2004.

CC-3 **[L.1.c.2] Personnel exhibited insufficient awareness of the impact of actions on reliability.**

In 1996 when the test method was changed from pressure-buildup to makeup-flow, it was recognized by the Appendix J coordinator that the new method, which involves pressurizing between the MSIVs, had the potential to produce an increased number of MSIV LLRT failures. However, the consequences of the changed test method were not fully felt, since there was only one as-found MSIV LLRT failure in 1996. Although there were multiple as-left MSIV LLRT failures in 1996 and 4 as-found MSIV LLRT failures in the subsequent outage (1998), the change in test method was not identified as a contributing cause. Therefore, the focus was increasingly on maintenance as the cause and cure of poor leakage rate performance. Even though maintenance has steadily improved since 1996, maintenance alone cannot be expected to compensate for the other factors that challenge MSIV LLRT performance.

CC-4 **[M.2.z.2] Design Analysis, Other**

The design of the MSIVs, while safe and adequately reliable, is not tolerant of less than optimal test method or minor deviations from certain critical dimensions. Pressurizing the valves with 26 psid in the reverse direction, rather than 45 psid in the accident direction, can have pronounced adverse effects on the measured leakage rate. Some tolerances inside the valve are a small as 0.001?, as in the packing follower to stem clearance.

Response to Specific CRG Instructions/Additional Considerations:

NONE

Extent of Condition:

Effects on equipment:
Susceptible equipment was considered potentially to be the population of globe valves that are leakage rate tested. There are 34 globe valves that are leakage rate tested in the IST program. Of these, 16 are 1.0 inch solenoid-operated valves. A PCRS search of these 16 component IDs produced one hit for a failed seat leakage test. Therefore, these 16 valves do not have an adverse trend in leakage rate and are not part of an extent of condition.

Six of the 34 globe valves are motor-operated. A PCRS search of these 6 component IDs produced zero hits for a failed leakage rate test. Therefore, these 6 valves do not have an adverse trend in leakage rate and are not part of an extent of condition.

The remaining 12 valves are air-operated globe valves. Eight of these 12 are the MSIVs, the subject of this investigation. The last 4 air operated globe valves that are leakage rate tested are two PCAC compressor inlet isolation valves and two reactor sample line isolation valves. A PCRS search of these 4 component IDs produced one hit for a failed seat leakage test. Therefore, these 4 valves do not have an adverse trend in leakage rate and are not part of an extent of condition.

Therefore, there are no equipment-related effects that could constitute an expanded extent of condition. The equipment identified in this CR, the eight MSIVs, is the whole extent of condition.

Effects on process or programs:
Since the safety function that is challenged by an MSIV failing its LLRT is leak-tightness of the primary containment, the process or program element that would justify an expanded extent of condition would be an adverse leakage trend in some other group of primary containment isolation valves, or in primary containment isolation valves as a whole. No such trend exists. Therefore, there are no process or program related effects that could constitute an expanded extent of condition.

Effects on human performance:
This is not a human-performance related event, as shown by the identified contributing causes.

Existing generic or common mode considerations:
The objective of this investigation was to identify, if possible, any generic, common, or root causes for the MSIV LLRT failures. No single common cause was identified. It was identified that the closing force of the actuator is a contributing cause. However, no other air-operated globe valves that are leakage rate tested have any history that suggests their actuator closing force is an issue.

Level of risk:
The risk associated with contributing cause #1 is low, based on the fact that the linkage between valve performance and a maintenance procedure that exceeds the normal standards for detail is unique to MSIVs.

The risk associated with contributing cause #2 is low, based on the determination that nearly all MSIV LLRT failures have been due to minor leakage that did not challenge the ability of the containment to provide an essentially leak tight barrier. LLRT limits have built-in conservatism, and these MSIV LLRT results have never resulted in exceeding the containment leakage rate surveillance limit (0.6 L_a). This assessment is strengthened by the pending approval of higher MSIV leakage rate criteria with the Alternate Source Term license amendment.

The risk associated with contributing cause #3 is low, based on the fact that MSIVs are unique in being tested in the reverse direction at reduced pressure. All other containment isolation valves are tested in the accident direction at full accident pressure. Therefore, there are no similar test method issues lying latent.

The risk associated with contributing cause #4 is low, based on the fact that LLRT performance for all other globe valves has been excellent. Globe valves tested in the reverse direction are the only containment isolation valves that could be vulnerable to LLRT failure resulting from marginal actuator seating force. Therefore, only the MSIVs are susceptible to this failure, and corrective actions have been initiated which address the design aspects, as well as providing test and maintenance methods that recognize and compensate for the design issues.

Related Operating Experience:

<u>Previous Related Conditions (ENVY)</u>:

Vermont Yankee has had a total of 14 as-found LLRT failures on MSIVs since the start of commercial operation in 1973. Four of these failures occurred prior to 1996, when the test method was a reduced-pressure-buildup test. The validity of this method relies on a number of assumptions that could not be verified and instrumentation that could not be obtained with the required accuracy. The low incidence of MSIV failures prior to 1996 is therefore more the result of a non-conservative test method than an indication of actual valve condition.

Starting in 1996, the test method was changed to the present method: makeup flow between the MSIVs at reduced pressure. This method fully complies with the VY Technical Specifications, and with the ANSI Standard 56.8 which governs containment isolation valve leakage rate testing. Of the 10 as-found failures beginning in 1996, 1 can definitely be attributed to test method; 3 failed because the acceptance criterion was established at 11.5 scfh, rather than the present 23 scfh; 3 have definitely identified mechanical causes; and 4 have no specifically identified cause (Attachment 3). The causes given for these four LLRT failures are: corrosion products/foreign material (1 valve in 2001 after >10 years of service); randomly deposited corrosion products or debris (1 valve in 2002 after 4.5 years of service); and minor inservice degradation (2 valves in 2004 after 6 and 7.5 years of service).

In 1998, MSIV-80B failed its LLRT (CR-VTY-1998-476) due to a galled stem. The WO 98-2519 notes describe a condition similar to that found in 2004. However, no corrective action was taken to identify and capture the critical measurements and dimensions in MSIVs. This same CR identified valve design, valve maintenance, and containment LLRT methods as contributing factors to the cause of LLRT failures in 4 MSIVs. However, none of the corrective actions established for CR-1998-476 addressed valve design or LLRT methods. The corrective actions focused on the effectiveness of the MSIV maintenance performed in 1998; mockup training for MSIV maintenance; and planning and scheduling activities associated with MSIVs.

In RFO-23, during 2002, the 'B' steam line MSIVs were tested a total of 7 times, and each valve was disassembled twice before achieving satisfactory LLRT results. CR-VTY-2002-2211 and CR-VTY-202-2212 were Category A CRs with RCA required. Contributing Cause number 2 (CC-2) was, "Procedure Needed But Not Written." A Corrective Action was assigned to Maintenance Support to incorporate the RFO-23 MSIV experience into an "ENVY procedure." No ENVY procedure for MSIV maintenance exists, although the commitment is closed. A significant level of effort was devoted to developing maintenance methods, practices, tooling, measurements, acceptance criteria, and required actions. In short, the work was done to produce a procedure, but the "procedure" is actually a Work Order template that generates step text. Work Order step text is not a procedure, and it is not subject to the same review and approval controls as a procedure. It is not sufficiently formal for MSIV work.

Related Industry OE:

Using the search string, "BWR and MSIV and (leakage or LLRT)," the INPO web site returned 158 hits. Virtually all of these hits describe MSIV LLRT failures at BWRs. This simply reinforces the informal consensus among pump and valve program owners that MSIV LLRT failures are a significant continuing issue. Certain changes to maintenance practices have been reported as contributing to more reliable LLRT performance, and these are addressed in the corrective actions proposed for this CR.

Although there is also consensus that the Wye-pattern globe valve is less-than-optimal from a design and application point of view, there are few LLRT failures directly attributable to valve design. Nevertheless, several valve modifications have been produced or endorsed by the valve manufacturer.

These modifications have all been implemented at Vermont Yankee. Two of these modifications could be expected to improve LLRT performance. Both the packing modification, which reduced packing friction; and guide rib and wear pad enhancements, which reduced seating friction, could be expected to improve MSIV LLRT performance. Their effectiveness at reducing LLRT failures is not yet demonstrated.

A survey by BWROG in 2001/2002 identified the following information that is relevant to this CR. A total of 6 BWRs, comprising 5 stations, have Rockwell-Edwards MSIVs. The most reliable predictor of LLRT results for these BWRs is whether the Technical Specification acceptance criterion is 11.5-23 scfh per valve or 100 scfh per valve. The 4 units with low acceptance criteria have as-found LLRT failure rates ranging from 12.5% (VTY) to 33% (Brunswick Unit 2). For the units with a limit of 100 scfh per valve, the failure rate is approximately 6.25%.

A significant fact is that one plant with high acceptance criteria has quite low average MSIV leakage rates. That plant tests in the accident direction at accident pressure on both the inboard and the outboard valve. The implication is that test method is directly related to as-found failure rates. When the test method closely simulates the actual accident condition, the failure rate is low. The between-the-valves test method, while conservative, apparently penalizes the valves under test and produces leakage rate results that indicate a higher failure rate than a more realistic test method would produce. Plants with the higher limit and that test between the MSIVs have fewer failures (due to the higher limit), but have relatively high MSIV leakage rates (a combination of test method, preventive maintenance weaknesses, and the failure to implement recommended design changes).

Corrective Actions:

Immediate/Interim Actions Completed	
Item #	**Action Taken**
CC-1	Although a procedure does not exist, much of the work required to develop one has been put into writing the MSIV maintenance guide.
CC-3	Main Steam Line plugs were purchased as a result of CR-VTY-2002-2211/2212. These plugs are superior to the old plugs in that they were installed in 4 hours total, and have been used at 45 psig to test steam line isolation valves in the HPCI and RCIC systems.
CC-2	The Alternate Source Term Amendment has been submitted and approval is expected prior to the end of 2004. This amendment will include the provision that MSIV leakage will be limited to a maximum of 62 scfh per valve and that testing will be in accordance with the Appendix J program, which means they will be tested in the accident direction, as all other containment isolation valves are tested.
CC-1	During RFO-24 many critical dimensions in MSIVs were identified, measured, and recorded.

Proposed/Assigned Corrective Actions					
Item #	**Action**	**CA Type**	**Assigned Department**	**Due Date**	**CA #**
CC-1	Develop a controlled MSIV VALVE maintenance procedure that adequately describes the required as-found dimensions, the acceptance criteria for the dimensions, the action required for out-of-tolerance dimensions, the disassembly process, the refurbishment process, the reassembly process, and the post-maintenance test requirements and acceptance criteria. This procedure will address both packing and valve internals maintenance. It is intended that this procedure will be a stand-alone reference for all MSIV maintenance work. This corrective action is assigned in CR-VTY-2004-955 CA-04. Therefore, it has no CA number for CR-2004-918.	LTCA	Maintenance Support	3/31/2005	n/a
CC-1	Develop a controlled MSIV ACTUATOR maintenance procedure that adequately describes the required as-found dimensions, the acceptance criteria for the dimensions, the action required for out-of-tolerance dimensions, the disassembly process, the refurbishment process, the reassembly process, and the post-maintenance test requirements and acceptance criteria. It is intended that this procedure will be a stand-alone reference for all MSIV Actuator maintenance work.	LTCA	Component Engineering	3/31/2005	02

Proposed/Assigned Corrective Actions					
Item #	Action	CA Type	Assigned Department	Due Date	CA #
CC-2	Implement the pending Alternate Source Term license amendment that contains higher MSIV leakage limits This is covered by BVY-03-70, Technical Specification Proposed Change 262.	LTCA	Code Programs	9/30/2004	03
CC-3	Develop a test method that safely and effectively tests both the inboard and the outboard MSIVs individually at accident pressure (P_a) in the accident direction. A method for as-found testing shall be developed, and a method for as-left testing, if the as-found test cannot be practicably used for as-left testing.	LTCA	Code Programs	12/1/2004	04
CC-4	Develop a plan, using the Engineering Request process, to identify and implement design changes to improve MSIV valve and actuator design for long-term reliability. This plan shall include planned MSIV modifications for RFO-25 and beyond. Vendor involvement is necessary and mandatory.	CA	System Engineering	8/31/2004	05

Personnel Interviewed:

Rich Booth, Component Engineering
Larry Doucette, Maintenance
Larry Prill, JAF
Joe Boivin, VY System Engineering
Rick Gerdus, VY Operations Chemist
Mike Ball, Design Engineering and former Appendix J Program Coordinator
Ted Underkoffler, Appendix J Program Coordinator

Keywords:

Documentation; Formality; PCLRT; LLRT, MSIV, Planning; White Board

Attachments:

ATTACHMENT 1: MSIV As-Found LLRT Failures By Year Since 1973
ATTACHMENT 2: Analytical Explanation of MSIV LLRT Results
ATTACHMENT 3: Data Analysis Based on the Analytical Model
ATTACHMENT 4: Barrier Analysis Worksheet
ATTACHMENT 5: Detailed Timeline
ATTACHMENT 6: Evaluation of MSIV LLRT Failure Mechanisms
ATTACHMENT 7: MSIV LLRT Details, 1996 – 2004

ROOT CAUSE TEAM MEMBERS

Rich Rusin
Jim Taylor
Larry Prill (JAF)
George Short
Mike Annett
Larry Lukens

REFERENCES

AP 0009, Event Reports
AP 0167, Operability Determinations
ENN-OP-104, Operability Determinations
ENN-LI-102, Corrective Action Process
OP 4261
PP 7204, Safety and Relief Valve Program
PP 7013, Inservice Testing Program

CR-VTY-2004-0918
"MSIV As-Found LLRTs Show An Adverse Trend"
Adverse Trend Common Cause Analysis

ATTACHMENT 1

MSIV AS-FOUND LLRT FAILURES BY YEAR

RFO	YEAR	AS-FOUND LLRT>23 scfh
	1973	2
	1974	1
4	1976	0
5	1977	0
6	1978	0
7	1979	0
8	1980	0
9	1981	0
10	1983	0
11	1984	0
12	1985	1
13	1987	0
14	1989	0
15	1990	0
16	1992	0
17	1993	0
18	1995	0
19	1996	1
20	1998	4
21	1999	0
22	2001	1
23	2002	2
24	2004	4

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ATTACHMENT 2

ANALYTICAL EXPLANATION OF MSIV LLRT RESULTS

Test volume is modeled as a fixed volume with a fixed orifice representing the inboard seat, and a fixed orifice representing the outboard seat. In the first test, the outboard orifice has a dP of 26 psid, and the inboard orifice has a dP of 26 psid, both from inside to outside of the test volume. On the second test, the outboard orifice has a dP of 26 psid, and the inboard orifice has a dP of 2 psid.

Since the flow through a fixed orifice is proportional to the square root of the pressure difference across the orifice, the flow through the outboard orifice is the same in both tests, while the flow through the inboard orifice is reduced by the square root of the ratio of the two pressure differences across the inboard orifice, namely 2 psid and 26 psid. This yields an inboard orifice flow of 0.277 times the initial flow when the inboard differential is 2 psid.

$$Q ? \sqrt{?P}$$
$$Q_1 ? \sqrt{?P_1}$$
$$Q_2 ? \sqrt{?\mathrm{P}_2}$$
$$\frac{Q_1}{Q_2} ? \sqrt{\frac{?P_1}{?P_2}}$$
$$\frac{Q_1}{Q_2} ? \sqrt{\frac{2}{26}} ? 0.277$$

Solving the two resulting equations simultaneously yields predicted outboard and inboard flows.

I ? O ? Combined Measurement

*0.277*I ? O ? Outboard Measurement*

By solving these equations simultaneously, the original values of inboard (I) and outboard (O) leakage can be obtained.

This analysis rests on an important assumption: the inboard and outboard orifice sizes do not change between the first, combined test and the outboard test.

When the inboard orifice size changes, it will become smaller, due to the pressurization sequence that pressurizes the inboard valve to 24 psig first, producing additional seating force on the inboard valve, and then pressurizes the test volume to 26 psig, achieving the required 2 psid for the test condition. The effect on predicted leakage is that the calculated outboard leakage decreases, usually going negative. A small change in inboard leakage is required to produce this effect in the calculation, typically a change from 0.277 to 0.15 or greater. A change from 0.277 to .015 corresponds to a reduction in the inboard valve flow area of 45.8%. The physical explanation for the negative number is that the inboard leakage has decreased due to tighter seating in the second test. This is caused by the pressurization sequence described previously.

The results of this analysis are the following: in every case, the inboard leakage predicted by the model is greater than the inboard leakage reported for the test, and the outboard leakage predicted by the model is less than the outboard leakage reported for the test.

This model has practical value only if it can show that a valve was worked unnecessarily. In RFO-19, the as-found LLRT for MSIV 86B was measured at 15.098. It was reworked, and a subsequent test passed at 9.24 scfh. However, the model shows that the initial inboard leakage was 13.2 and the initial outboard leakage was 11.4. Following the repair, the model shows that the inboard leakage was 14.0, and the outboard leakage was 5.4. It appears that the worst valve of the pair was the inboard valve, and the fact that fixing the outboard valve reduced the total line leakage to an acceptable value was fortuitous.

In RFO-20, the initial leakage reported by LLRT for the 'C' main steam line was 93.3 for the outboard and 406.7 for the inboard. Both valves were worked. The model shows that the outboard valve initially had little or no leakage. However, it had been previously scheduled for maintenance and modification, so this difference didn't result in unscheduled work.

In RFO-23, the 'B' main steam line as-found LLRT result was 35 scfh for the outboard and 46.4 for the inboard. Both valves were worked. The model shows that the outboard valve initially had little or no leakage, and that it was worked unnecessarily. It failed a subsequent test, resulting in a second disassembly.

In RFO-24, the B main steam line as-found LLRT result was 43.8 scfh for the outboard and 119.0 scfh for the inboard. The outboard valve was not worked, because it was realized that the pressurization sequence affects the indicated leakage rate. The model shows that the outboard valve initially had little or no leakage. This was confirmed by a LLRT that showed less than 1.0 scfh on the outboard valve.

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ATTACHMENT 3

DATA ANALYSIS

The following table is the spreadsheet that solves the simultaneous equations for all tests since 1996 that determined individual leakage rates for the inboard and outboard valves. The acceptance criterion changed in 1999 (RFO-21) from 11.5 scfh per valve to 23 scfh per valve, in accordance with Technical Specifications.

		Reported	CALCULATED
RFO-18	Inboard + Outboard	16.8	
Line D	Outboard (86)	16.3	16.1
As-Found	Inboard (80)	0.4	0.6
	Evaluation: No change; both passed on current criteria.		

		Reported	CALCULATED
RFO-19	Inboard + Outboard	33.4	
Line A	Outboard (86)	25.5	22.5
As-Found	Inboard (80)	7.9	10.9
	Evaluation: 86A would have passed marginally with a better test.		

		Reported	CALCULATED
RFO-19	Inboard + Outboard	21.7	
Line A	Outboard (86)	5.1	-1.3
As-Left	Inboard (80)	16.7	23.1
	Evaluation: No change in result; 80A still needed work.		

		Reported	CALCULATED
RFO-19	Inboard + Outboard	24.7	
Line B	Outboard (86)	15.1	11.4
As-Found	Inboard (80)	9.6	13.2
	Evaluation: Both passed with current acceptance criteria. However, 86B was worked. 80B actually had the higher leakage.		

		Reported	CALCULATED
RFO-19	Inboard + Outboard	19.3	
Line B	Outboard (86)	9.2	5.4

As-Left	Inboard (80)	10.1	14.0

Evaluation: 86B leakage dropped significantly; 80B leakage didn't change. Worked the wrong valve, but the line passed.

		Reported	CALCULATED
RFO-19	Inboard + Outboard	33.2	
Line C	Outboard (86)	24.2	20.7
As-Left	Inboard (80)	9.1	12.5

Evaluation: 86C was worked; it was actually greater than the acceptance criterion in use in RFO-19. Using current criteria, it would have changed from fail to pass, using a better test method.

		Reported	CALCULATED
RFO-19	Inboard + Outboard	19.4	
Line D	Outboard (86)	16.1	14.9
As-Left	Inboard (80)	3.2	4.5

Evaluation: 86D exceeded the criterion in use in RFO-19. No change in result.

		Reported	CALCULATED
RFO-20	Inboard + Outboard	73.0	
Line B	Outboard (86)	32.5	17.0
As-Found	Inboard (80)	40.5	56.0

Evaluation: 86B exceeded the criterion in use in RFO-20. No change in result.

		Reported	CALCULATED
RFO-20	Inboard + Outboard	500.0	
Line C	Outboard (86)	93.3	-62.8
As-Found	Inboard (80)	406.7	562.8

Evaluation: 86C would not have failed. However, it was scheduled for maintenance and modification anyway.

		Reported	CALCULATED
RFO-22	Inboard + Outboard	18.8	
Line C	Outboard (86)	8.8	4.9

As-Found	Inboard (80)	10.0	13.9

Evaluation: Both passed; no change

		Reported	CALCULATED
RFO-22	Inboard + Outboard	87.7	
Line D	Outboard (86)	12.5	-16.3
As-Found	Inboard (80)	75.2	104.0

Evaluation: Only 80D was worked. No change in result.

		Reported	CALCULATED
RFO-23	Inboard + Outboard	81.4	
Line B	Outboard (86)	35.0	17.2
As-Found	Inboard (80)	46.4	64.2

Evaluation: 86B would have passed. It was worked unnecessarily.

		Reported	CALCULATED
RFO-23	Inboard + Outboard	225.0	
Line B	Outboard (86)	60.0	
As-Left #1	Inboard (80)	165.0	

Evaluation: 80B was clamped shut. The 86B result is valid.

		Reported	CALCULATED
RFO-23	Inboard + Outboard	20.0	
Line C	Outboard (86)	8.8	4.4
As-Found	Inboard (80)	11.3	15.6

Evaluation: Both passed; no change in result.

		Reported	CALCULATED
RFO-24	Inboard + Outboard	28.8	
Line A	Outboard (86)	26.3	
As-Found	Inboard (80)	2.5	

Evaluation: The sequence of pressurization was changed. The 86A result is valid.

		Reported	CALCULATED
RFO-24	Inboard + Outboard	162.9	
Line B	Outboard (86)	43.9	-1.8
As-Found	Inboard (80)	119.0	164.7

Evaluation: 86B would have passed. This was demonstrated by test after clamping 80B shut.

		Reported	CALCULATED
RFO-24	Inboard + Outboard	85.0	
Line C	Outboard (86)	75.2	71.4
As-Found	Inboard (80)	9.8	13.6

Evaluation: 86C was an actual failure. No change in result..

ATTACHMENT 4

BARRIER ANALYSIS WORKSHEET

CONSEQUENCE(S)	BARRIER(S) THAT SHOULD HAVE PRECLUDED	BARRIER ASSESSMENT [WHY THE BARRIER(S) FAILED]
Emergent, Unnecessary MSIV maintenance	Consistent, documented maintenance procedures	No procedure exists.
Excessive LLRT Failures	Test Method; Change Management; Robust Valve and Actuator Design	There was inadequate appreciation of the potential for the change in test method to compromise test results.
	Valve Orientation	Plant piping configuration is not consistent with the orientation intended by the valve manufacturer
	Correct Clearances and Seat-to-Guide Alignment; Seat Concentricity; Seat Contact	There are no procedure-driven measurements with acceptance criteria and actions for non-conformance.
Rework: Assembly and disassembly methods can be inconsistent and dependent on individual worker's knowledge and skill.	Procedures Training Workmanship	Procedures do not exist for valve disassembly, capturing as-found dimensions and condition, comparison of as-found data to acceptance criteria, comparison of as-left dimensions to acceptance criteria, and reassembly. This highly sensitive maintenance evolution relied on WO step text.

CONSEQUENCE(S)	BARRIER(S) THAT SHOULD HAVE PRECLUDED	BARRIER ASSESSMENT [WHY THE BARRIER(S) FAILED]
Stem Galling Leading to Binding	Stem / Packing Follower / Packing Spacer / Seat Centerline Alignment;	There is no procedural requirement for consistent dimensional measurements; comparison to acceptance criteria; restoration of non-conforming measurements to within specification.
	Packing Follower and Packing Spacer clearances	There was a lack of understanding by the manufacturer and the industry of the precise factors that must be controlled (providing lateral support for the stem without metal-to-metal contact).

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ATTACHMENT 5
Detailed Timeline

The following table shows by RFO and by year the number of as-found MSIV tests that exceeded 23 scfh. Although the individual valve criterion prior to 1999 was 11.5 scfh per valve by Technical Specification, the value of 23 scfh was chosen as the criterion for consistency of comparison. This is the maximum that a single valve may leak and still permit the total leakage criterion of the current Technical Specification to be met.

YEAR	EVENT
1973	2 MSIV as-found LLRT failures
1974	1 MSIV as-found LLRT failure
1976 – 1984	0 MSIV as-found LLRT failures
1985	1 MSIV as-found LLRT failure
1989	Packing modified from 10 rings asbestos to 5 rings graphite
1987 – 1995	0 MSIV as-found LLRT failures
1996 RFO-19	CR-VTY-1996-0077 and LER 96-04 identified that MSIV LLRT method was not compliant with the licensing basis. Test method changed to the current 26 psig "between the valves" method, which tests the inboard valve in the reverse direction and continues to test the outboard valve in the accident direction at reduced pressure.
1996 RFO-19	1 MSIV as-found LLRT failure (attributable to test method)
1996 RFO-19	4 MSIV stellite junk rings removed; packing spacer increased from 3.625 to 4.041 inches
1998 RFO-20	4 MSIV as-found LLRT failures (2 attributable to test method)
1998 RFO-20	Remaining 4 MSIV stellite junk rings removed; packing spacer increased from 3.625 to 4.041 inches
1998 RFO-20	MSIV 80B galled stem (identified as the cause of the LLRT failure)
1998 RFO-20	Live-loaded packing, smart-stem strain gauges, and disk-stem separation prevention modification installed on B & C MSIVs
1999 RFO-21	0 MSIV as-found LLRT failures
1999 RFO-21	Live-loaded packing, smart-stem strain gauges, and disk-stem separation prevention modification installed on A & D MSIVs
2001 RFO-22	1 MSIV as-found LLRT failure (not attributable to test method)
2002 RFO-23	2 MSIV as-found LLRT failures (1 attributable to test method)
2004 RFO-24	4 MSIV as-found LLRT failures; corrected back to 3 MSIV as-found LLRT failures (none attributable to test method)
2004 RFO-24	MSIV 80B galled stem; CR-VTY-2004-955 (identified as the cause of the LLRT failure)

ATTACHMENT 6
Evaluation of LLRT failure mechanisms

The root cause analysis performed for CR-VTY-2002-2211/2212 identified the following potential mechanisms or factors that could lead to LLRT failures. The discussions have been updated to make them current with available information as of RFO-24.

- **Seat Geometry:** Vermont Yankee (Rockwell/Edwards) seat geometry is cone-in-cone with full seat contact. Although this geometry is less forgiving than others with respect to seat leakage should misalignment occur, seat geometry as a parameter was judged to be not a primary contributor to high leakage.

- **Inadequate Actuator Loading:** Inadequate actuator loading was considered a potential contributor to MSIV leakage since increased actuator loading can reduce seat leakage. It should be noted that net seat loading is reduced on the inboard valve when LLRT test pressure is applied between the valves. Actuator loading, although not a primary contributor to high leakage, may improve leakage performance under low leakage conditions if increased.

- **MSIV Aging:** The age of MSIVs in BWR plants varies widely in terms of actual life and service time. This was considered a potential contributing factor to LLRT failure since it can be postulated that the effect of wear on valve and actuator internals as a function of time can have an adverse impact on LLRT performance. This theory was subsequently dismissed, however, on the basis that the LLRT failure data clearly show that MSIVs of all ages have had failures without significant differences in the ratio of tests passed to tests failed. The concept of "age" in a BWR MSIV is somewhat specious anyway. Since MSIVs are routinely disassembled, examined, refurbished, and reassembled to original manufacturer's specifications, it isn't clear what could "age" in an MSIV. At VY, there is an apparent correlation between service time and LLRT failure. This is the only age-related correlation that could be established.

- **Valve Damage:** Valve damage has resulted from steam flow and improper maintenance; however, steam cutting or erosion of the main seats has not been observed during valve inspections since 1996. Flow-induced damage can include valve stem bending, valve stem disc separation and damage to the guide ribs. Improper maintenance has resulted in the galling of the yoke rods, valve stem and pitting of the valve stem, as well as damage to the valve seat. Damage to the stem affects stem leak tightness, which is not related to main seat leakage but could affect valve cycle time and could reduce the effectiveness of the actuator force. These comments apply to BWRs generally, but not to VY specifically. There are no documented or reported instances at VY of stem damage affecting measured MSIV stroke time.

- **LLRT Pressurization Method:** Currently, the most common method among BWRs for applying LLRT pressure is to pressurize between the inboard and outboard MSIVs. This is considered a potential LLRT failure contributor for inboard valves that modestly exceed the acceptance criteria. This is because the applied pressure is in a direction that is opposite to the flow that will oppose the actuator force and decrease the net seat loading. This factor can be regarded as a legitimate potential contributor only for low leakage failures on inboard valves.

- **Closing Procedures:** Present BWR practices vary from closing the MSIVs while the system is pressurized and flow exists to closing them after the system has been fully depressurized and no flow exists. The assistance to closure provided by flow and pressure may assist moderately leaking valves in passing the LLRT. At VY, the MSIVs are fast-closed shortly before the reactor coolant temperature reaches 212°F. This is the close stroke that establishes the test boundary for the as-found LLRT. This method is conservative compared to the conditions when primary containment isolation would actually be required during an event.

- **Foreign Deposits:** Heavy corrosion deposits or construction debris have been found in some valves after disassembly, following failure of pre-operational leak rate tests. Such material interfered with closure of the valve and produced excessive leakage. However, after plants have been in operation, subsequent accumulations have been insignificant. Because this foreign material should only exist during pre-operational conditions, this situation is normally judged to be a non-contributing factor in LLRT failure during outages at operating plants.

- **Piston Rotation:** Valve piston rotation was considered a potential contributor to the MSIV leakage problem since this phenomenon has been observed. Although not directly linked with through seat leakage, it could become a contributing factor because seating surfaces are not constant in relation to one another. This could produce erratic LLRT results since consistent seat contact may not be achieved. Continual rotation of a piston could cause wear between the piston and body guiding surfaces, which could affect clearances and operation. This condition has not been observed in the size MSIVs at Vermont Yankee. The evidence of this is a lack of wear rubbing on the piston or valve body upper bore. The OEM has confirmed that this condition is only prevalent in larger valves and is a direct result of how much of the piston nose is subjected to (within) steam flow.

- **Valve Orientation:** The MSIV stem travels in a 45-degree angle relative to the pipe centerline. This makes valve maintenance more difficult and increases the chance of damage to the valve internals. For two MSIVs (V2-80A and V2-80D), the stem is further rolled to the side by as much as 30 degrees. In this arrangement, the piston is not supported by a rib guide at the base of the piston; instead, it is cradled between two rib guides. This potentially increases the misalignment between the centerline of the piston and the centerline of the seat. This increases the required movement (sliding against friction) for the piston to seat properly.

- **Excessive Clearances/Seat to Guide Misalignment:** A designed and specified diametrical clearance exists between the piston and guides. When the valve is installed in the plant in a horizontal pipe run, the piston slides on the guides by gravity. This effectively misaligns the piston to main seat by half the original diametrical clearance. This forces the main body seat to perform the final guiding of the piston into the seat. The piston hits the bottom part of the body seat first as it enters the seating area and then must slide along the seating surface toward the main seat centerline to make full contact with the body seat. In addition, previous seat maintenance, guide rib wear or damage may increase the distance the piston will have to travel when it enters the seat.

Since the direction of piston movement during seat engagement is significantly different from the direction of the actuator applied force during seat engagement, the net force moving the piston in this direction is reduced. Therefore, any opposing forces (i.e., friction) potentially could prevent the sliding movement from taking place. This type of valve movement contrasts with a valve in an angled line, where the actuator is vertical, rather than angled at 45° as in the BWRs. In an angled line, the actuator is vertical and drops the piston vertically, directly into the seat. No BWRs with Rockwell-Edwards MSIVs have this more-advantageous vertical actuator configuration. Modifications initiated by the manufacturer to compensate for this geometry have included changes to the guide ribs and additional welded steel "postage stamp" pads to guide the disk and reduce sliding friction into the seat.

In addition, seat to piston centerline misalignment can be related to leakage in the "as found" condition following plant cycle operation. The refurbishment of all MSIVs in 1998 and 1999 reduced the design diametrical clearance between the piston and bore from 0.030?-0.040? to 0.015?-0.018?. This along with complete line boring of the valves to achieve a maximum of 0.0025? total indicated runout (TIR) seat to guide rib concentricity provides assurance that best achievable alignment between seat and ribs is present. In 2001, the bore to seat TIR for V2-80D was found to be within 0.001? of the 1999 as-left values indicating that alignment is maintained and that there is no appreciable distortion induced by thermal cycling. Although the 80B/86B valves were not checked in 2001 for TIR bore to seat, the lapping setup in the valve body confirmed that there was no concentricity problem between the seat and bore; had there been, low spots would have been evident.

- **Lack of Concentricity:** Lack of adequate roundness of the mating seats and improper concentricity of the seats with the guide surfaces were considered possible contributors to seat leakage. Experience has shown that although the roundness may be acceptable, the seating surface on the piston may be eccentric relative to the piston outside diameter. This eccentricity, when combined with improper rib guidance or piston rotation, could be a significant contributor to low leakage LLRT failures.

- **Incorrect Seat Contact:** It is clear that for the MSIV to pass the LLRT, the mating seats must be in close contact. Any mechanism that might be identified as a possible means for preventing this contact could be a probable cause for LLRT failure. As expected, experience has shown that an eccentric, excessive seating friction could prevent full closure and could cause piston cocking and excessive leakage. One means of creating this gap would involve misalignment between the centerline of the supporting guide ribs and seats, as well as possible cocking of the piston due to improper guidance related to clearances and excessive drag or friction forces. At Vermont Yankee the reduced diametrical clearances limit the contribution to LLRT failure to the minimum achievable. The OEM allows no less than 0.015? clearance due to thermal expansion and binding concerns.

- **Excessive Coefficient of Friction/Corrosion:** Excessive coefficient of friction due to oxidation or corrosion buildup on the guides and seating surfaces was considered a potential contributor to the MSIV leakage problem. This is because it has been demonstrated that some valves that fail LLRT can be brought within acceptable limits merely by cleaning these mating surfaces. It appears that there is no effective way to prevent corrosion, and therefore, it must be compensated for. Additionally, it has been shown that excessive friction may not be a problem in itself but may act in combination with several other factors. As the friction forces increase, the sliding of the piston to the main seat is impaired to the point that when the sliding motion ceases, the piston tilts, allowing the top of the piston to engage the upper valve bore before seating can be achieved. This locks the piston and restricts further movement. This may be a primary factor in LLRT leakage.

ATTACHMENT 7

The following table lists the causes identified for the MSIV as-found LLRT failures from 1996 through 2004.

YEAR	VALVE	LEAKAGE	VTY-CR-	CAUSE
1996	V2-86A	25.5	1996-627	Component Aging
1998	V2-80B	40.5	1998-476	Galled Stem; stuck
1998	V2-86B	32.5	1998-476	Main body seat non-concentricity; other dimensions out of spec
1998	V2-80C	407	1998-476	Valve body, seat defects
1998	V2-86C	93	1998-476	Main body seat non-concentricity; other dimensions out of spec
1998	B AND C MSL	CR-1998-476 also identified design deficiencies; poor workmanship in 1996; and the reverse testing of the inboard MSIV as causes. These are common to all 4 failed MSIVs in 1998.		
2001	V2-80D	75	2001-888	Foreign material on main seating surface; pilot leaked
2002	V2-80B	46	CR 2002-2211/2212 identified randomly deposited debris/corrosion products; and no procedure for disassembly, blue check, or reassembly of MSIVs	
2002	V2-86B	35		
2004	V2-86A	26	2004-836	Minor service induced degradation
2004	V2-80B	119	2004-841	Severe stem galling
2004	V2-86C	75	2004-839	Minor service induced degradation

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USNRC

September 17, 2004 (10:08AM)

OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Docket No. 40-8027-MLA-4
	)	
SEQUOYAH FUELS CORPORATION	)	Re: Request to Amend Source
(Gore, Oklahoma)	)	Material License No. SUB-1010
	)	

NOTICE OF WITHDRAWAL

Notice is hereby given that effective September 15, 2004, I will withdraw my appearance in the aboe-captioned proceeding. All mail and service lists should be amended to delete my name after that date.

Respectfully submitted,

Giovanna M. Longo
Counsel for NRC Staff

Dated at Rockville, Maryland
this 15th day of September, 2004

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	Docket No. 40-8027-MLA-4
	)	
SEQUOYAH FUELS CORPORATION (Gore, Oklahoma)	)	Re: Request to Amend Source Material License No. SUB-1010

NOTICE OF APPEARANCE

Notice is hereby given that the undersigned attorney herewith enters an appearance in the above-captioned matter. In accordance with 10 C.F.R § 2.713(b) (2003 Edition), the following information is provided:

Name:	Angela B. Coggins
Address:	U.S. Nuclear Regulatory Commission Office of the General Counsel Mail Stop: O-15D21 Washington, D.C. 20555
Telephone:	301-415-1574
Facsimile:	301-415-3725
E-Mail Address:	abc1@nrc.gov
Admissions:	Louisiana North Carolina
Name of Party:	NRC Staff

Respectfully submitted,

Angela B. Coggins

Angela B. Coggins
Counsel for NRC Staff

Dated at Rockville, Maryland
this 15th day of September, 2004

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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SEQUOYAH FUELS CORPORATION	)	Re: Request to Amend Source
(Gore, Oklahoma)	)	Material License No. SUB-1010
	)	

CERTIFICATE OF SERVICE

I hereby certify that copies of the "NOTICE OF WITHDRAWAL" of Giovanna M. Longo and "NOTICE OF APPEARANCE" of Angela B. Coggins in the above-captioned proceeding have been served on the following by deposit into the United States mail, or through deposit in the Nuclear Regulatory Commission's internal mail system as indicated with a single asterisk, or with a double asterisk by hand delivery on this 15th day of September, 2004.

Administrative Judge*
Charles Bechhoefer
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Mail Stop: T-3F23
Washington, D.C. 20555

Adjudicatory File*
Atomic Safety and Licensing Board
Mail Stop: T-3F23
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Office of the Secretary**
ATTN: Rulemaking and Adjudications Staff
U.S. Nuclear Regulatory Commission
Mail Stop: O-16G15
Washington, D.C. 20555

Atomic Safety and Licensing Board Panel*
U.S. Nuclear Regulatory Commission
Mail Stop: T-3F23
Washington, D.C. 20555

Administrative Judge*
Anthony J. Baratta
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Mail Stop: T-3F23
Washington, D.C. 20555

Mr. Craig Harlin
Sequoyah Fuels Corporation
P.O. Box 610
Gore, Oklahoma 74435

Kelly Burch, Esq.
Assistant Attorney General
State of Oklahoma
Environmental Protection Unit
4545 North Lincoln Boulevard
Suite 260
Oklahoma City, OK 73105-3498

Office of Commission Appellate
Adjudication**
U.S. Nuclear Regulatory Commission
Mail Stop: O-16G15
Washington, D.C. 20555

Alvin H. Gutterman, Esq.
Morgan, Lewis & Bockius, LLP
1111 Pennsylvania Avenue, N.W.
Washington, D.C. 20004

Giovanna M. Longo
Counsel for NRC Staff

Angela B. Coggins
Counsel for NRC Staff